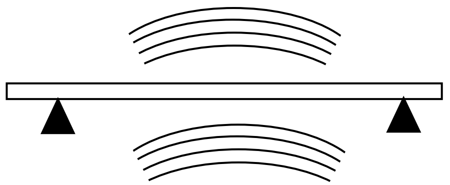
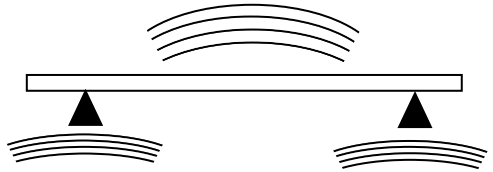
Noise control

The noise source **the transmission path** → **the receiver**

- Air-borne sound transmission
  - Sound absorption
    (converting sound energy to heat)
  - Sound insulation
    (by reflection)



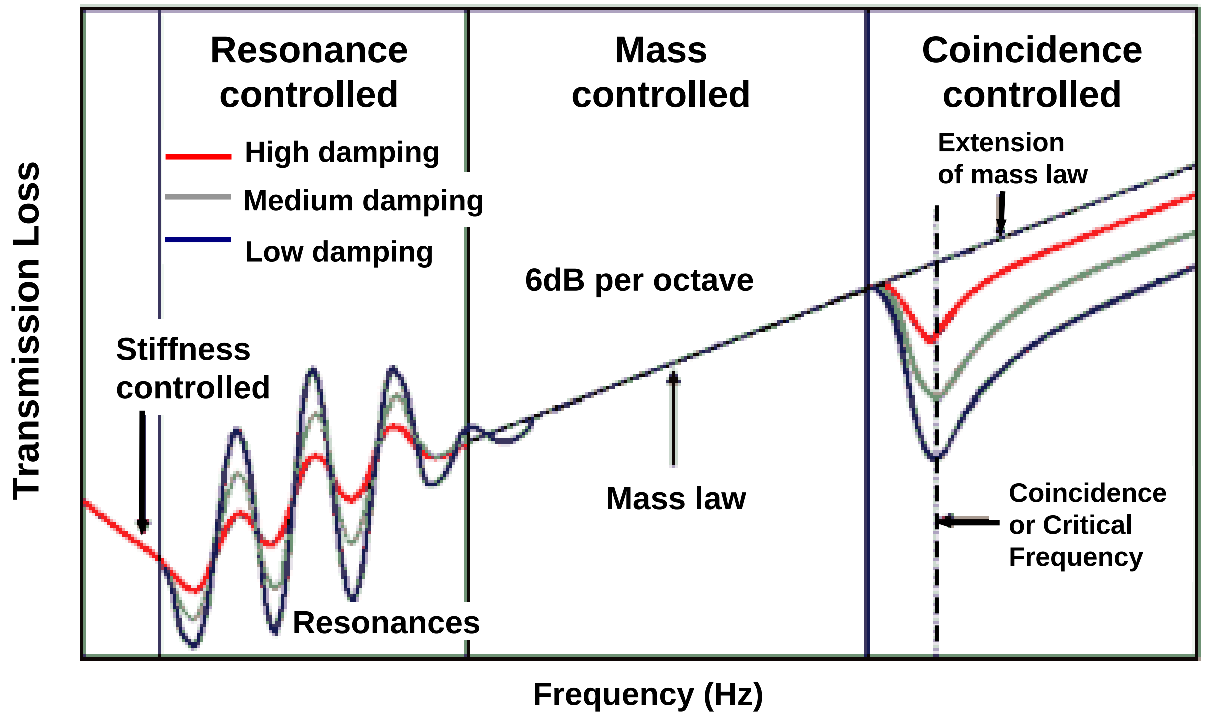
- Structure-borne sound transmission
  - Isolation between source and structure
  - Vibration damping
    (converting vibration energy to heat)



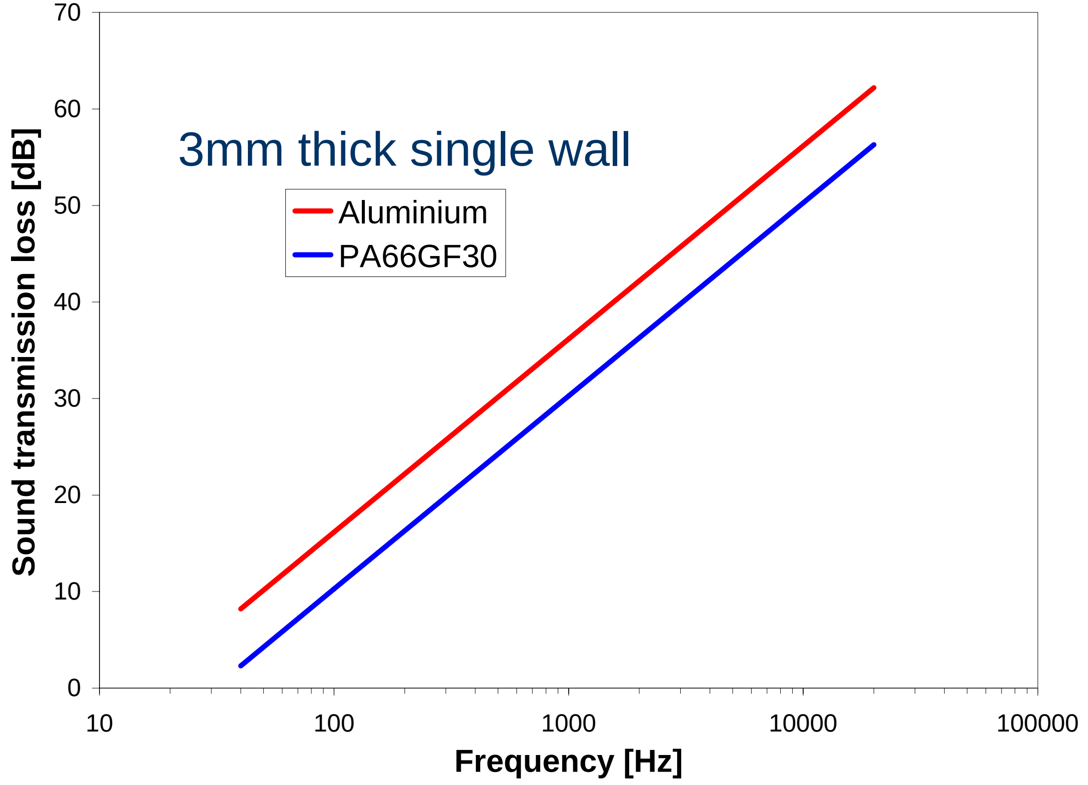
Sound Transmission Loss

$$R \equiv 10 \log \frac{1}{\tau}$$

τ: Sound transmission coefficient
Perfect transmission: $\tau \to 1$ and $R \to 0$



Mass-controlled transmission loss

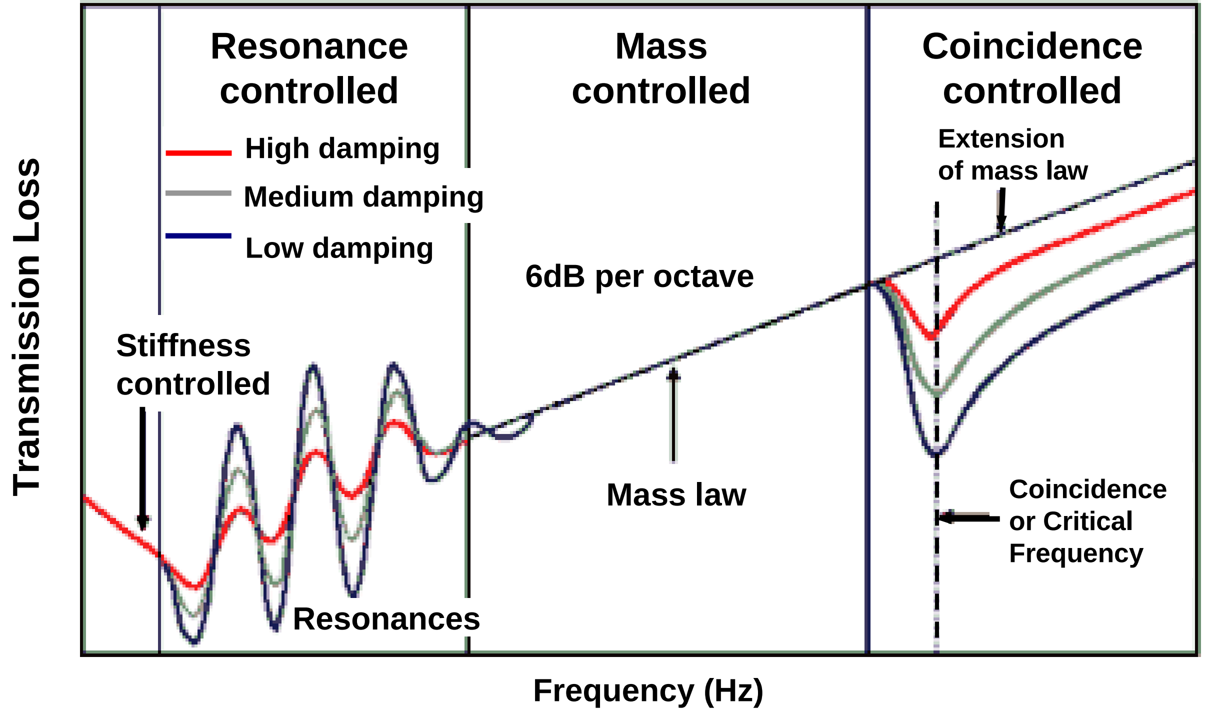


The noise reduction is governed by the mass per unit area

Sound Transmission Loss

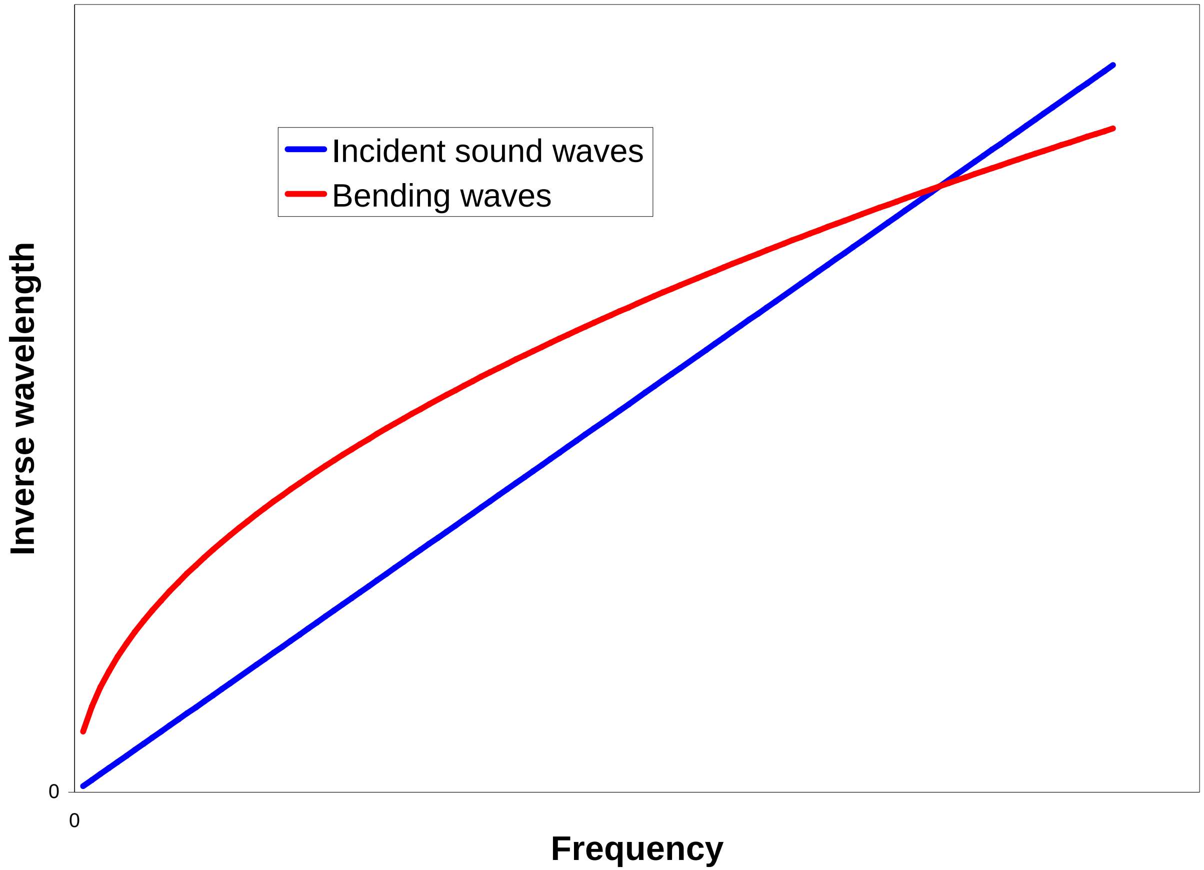
$$R \equiv 10 \log \frac{1}{\tau}$$

τ: Sound transmission coefficient
Perfect transmission: $\tau \rightarrow 1$ and $R \rightarrow 0$



Coincidence

Sound wavelength = Bending wavelength



Coincidence

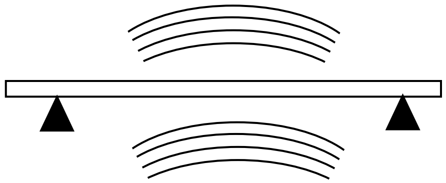
The lowest frequency at which coincidence occurs is the *critical frequency*

For a homogeneous isotropic plate: $f_c \propto (\rho/Eh^2)^{1/2}$

f_c for 3 mm thick plates: 9 kHz (PA66GF30), 4 kHz (aluminium), 18 kHz (lead)

- Air-borne sound
  - The wall becomes almost “transparent” to the sound wave, i.e. the sound transmission drops
- Structure borne sound
  - a wall excited in bending at the critical frequency will strongly tend to radiate a corresponding acoustic sound wave

Control of air-borne noise



- Air-borne sound transmission
  - Sound absorption (converting sound energy to heat)
  - Sound insulation (by reflection)

↳ high transmission loss

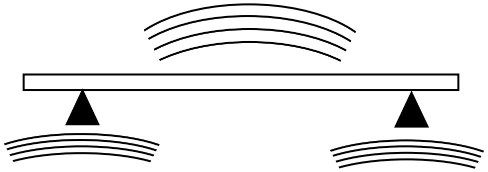
Sound reflection

Large change in impedance
$Z = \rho v \cong (\rho E)^{1/2}$ (for isotropic elastic solid)

Sound absorption

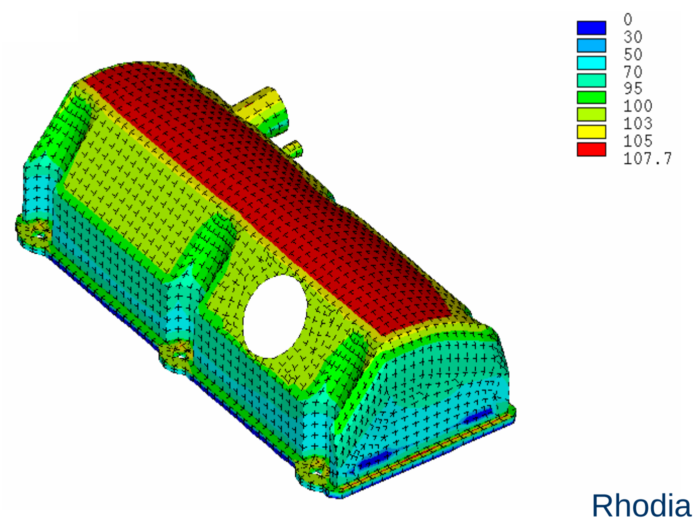
porous fibre mats, cellular polymers

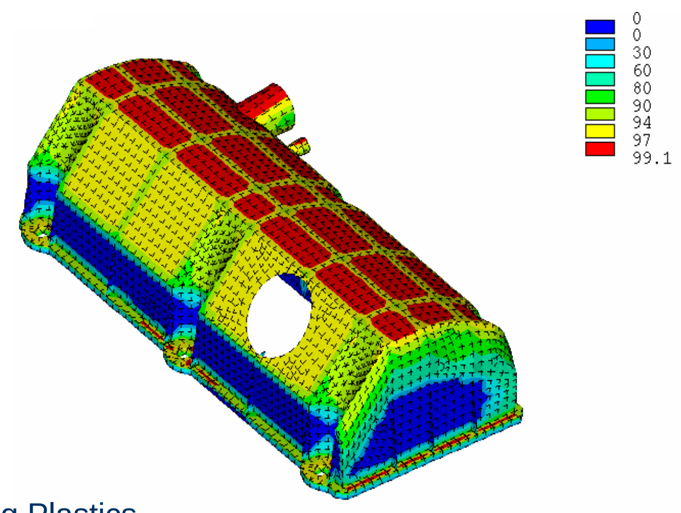
Control of structure-borne sound



- Control of resonance (detuning)
  - mass
  - stiffness

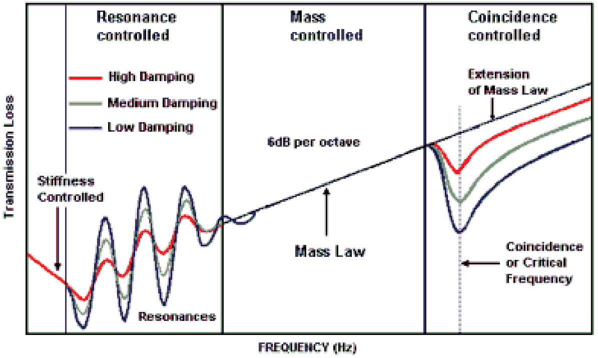
- Control of stiffness (reduce the vibration amplitude)
  - thickness
  - ribs





Rhodia Engineering Plastics

Conclusions



- Mass-controlled regime: No weight-saving with plastics if the design is the same
- Resonance and coincidence: Plastics have lower stiffness, but higher intrinsic damping than metals
  - Lower eigenfrequencies. Larger deformations in general, but higher damping at eigenfrequencies.
  - Higher critical frequencies. Higher damping.
- Smart designs
  - Sound absorption and sound reflection (e.g. use of double-wall structure)
  - Vibration control (stiffness, structural damping)
- No general solution for noise control